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ASA, Floating Room

DESIGN OF SPECIAL ROOM

#3.

[redacted] Project No. A-157 25X1
January 31, 1961

This is Progress Report No. 1157-8 on [redacted] Project No. A-157 25X1 for the 3-1/2-month period of October 15, 1960 to January 31, 1961. The purpose of this project is the development of a system for erecting a room using demountable panels. The room when built is to have a high degree of electromagnetic shielding and high sound transmission loss.

EXTENSION

This project has been extended to May 31, 1961, at an estimated additional cost of $15,471. This extension covers principally a program to develop a single door and door seal having a sound transmission loss comparable to that of the wall structure so far developed. This is in accordance with the sponsor's preference for a single door rather than the double door being used for the first prototype room.

RIVERBANK LABORATORIES TESTS

Sound transmission tests were conducted at Riverbank Laboratories in the week of October 17, 1960, to determine the effect of substituting 0.032" aluminum for the 20-gauge steel sound pans in the basic wall structure developed and tested previously. The entire structure, including the Lindsay channels and RF sheet, the outer skin, and the interior floated sound pans and filler panels, was of aluminum. The weight of the all-aluminum Riverbank test panel was 3.9 lbs per sq ft, as against 5.0 lbs per sq ft for the same panel with steel sound pans. The schedule included a test of the aluminum RF sheet and outer skin with no sound pans, a repeat for check purposes of a previous test of the assembly with steel pans, and tests of the effect of stiffening ribs on the aluminum sound pans. These were tested with no ribs, one transverse rib, and three transverse ribs, respectively. The ribs made no significant difference in the transmission loss. The complete data are given in Table 1 and the accompanying charts, and are summarized as follows:

Test No.		Weight lbs/sq ft	Average TL
61-39	Aluminum RF sheet and outer skin	2.6	32 db
61-43	Complete wall, aluminum sound pans	3.9	48
61-40	Same, except steel sound pans	5.0	50
60-145	Same, previous test		51

These tests indicate that a saving of about 1 pound per square foot may be realized by substituting aluminum for steel sound pans, with a reduction of only 2 or 3 db in average transmission loss. The data in Table 1 shows that the reduction in TL at the speech frequencies (above 500 cycles) was even smaller, so that the all-aluminum wall should be equally as effective as the wall with steel sound pans against speech intelligibility.

ERECTION OF PROTOTYPE ROOM

Completion of the fabrication and erection of the prototype room at the plant of Ace Engineering and Machine Co. was carried out essentially as outlined in the previous Progress Report No. 7. Erection was completed to the point where performance tests could be made on December 20. The design specifications for the room as completed at this time were in accordance with those listed in our Progress Report No. 7, with the following exceptions:

Sound Pans - The entire ceiling and the wall opposite the door were built with aluminum sound pans. All others were steel. This was done to compare steel and aluminum sound pans in field performance tests. Stiffening ribs were added to all sound pans.

Doors - Rysdon gasketed stops were omitted from the outer door.

Air Conditioning Unit - Unit had not been supplied at this time. Ventilating openings in outer wall of room were covered with metal caps to simulate acoustical effect of ductwork.

Interior Finish - Carpet and acoustical tile were not installed at this time. In the meantime, the sponsor had changed the specification for wall finish from decorative plywood to a flexible sheet plastic imitation wood finish to be adhered directly to the sound pans and filler panels.

Furniture - The sponsor had also added furnishings to the previous specifications, these to consist of a table, chairs, bookshelves, chalkboard, projection screen, drapes, and a clock. None of these were installed as of December 20.

After the performance tests of December 20, the room was dismantled and re-erected at Bell Telephone Laboratories during the period from January 19 to 26, 1961. At this time all interior finish and furnishings were installed or on hand ready for installation. The room as erected at this time was the same as before except that all wall panels had steel sound pans, and some minor modifications had been made to the ventilating panel to improve the sound attenuation.

As a result of tests and experience up to January 31, it was concluded that before final delivery of the prototype room, the ventilating panel should be modified to provide higher sound attenuation and easier erection, and that the interior filler panels between the sound pans should be redesigned so as to lock into place when installed so that they could not be removed without causing visible damage. This was believed desirable by the sponsor in the interest of security.

In our previous Progress Report, No. 7, it was stated that the cost estimate by Ace Engineering for completing the prototype room had been raised from the original estimate of May 6, 1960, in the amount of $21,105 to a figure of $25,305, in view of changes in the room specifications and added scope of the contract desired by the sponsor. Both figures, however, were based on the fabrication of a 50 percent overage in all modular room components. The sponsor has since withdrawn this request for overage, and Ace Engineering have verbally restored the cost estimate to the original figure.

PERFORMANCE TESTS - ACE ENGINEERING

In accordance with the Foundation's contract with the sponsor, performance tests for sound transmission and electromagnetic shielding were carried out on the prototype room. These tests were conducted on December 20, 1960, at the Ace Engineering plant.

25X1

The tests of electrical shielding were supervised by [redacted] representing the Electronics Research Division of the Foundation. His report is quoted below:

"Measurements of shielding effectiveness of an enclosure made in accordance with Specification MIL-S-4957 were witnessed at Ace Engineering and Machine Co. on 20 December 1960. At 400 mc., RF illumination of the entrance side yielded an effectiveness of 112 db, whereas the other three sides were better than the measurement capability of 116 db. Also at 400 mc., a reverse measurement procedure was utilized with the source antenna at the center of the enclosure and the pickup antenna outside and 8 feet away from the entrance wall. This measurement yielded only 94 db, but the lower value is to be expected from the nature of the measurement.

At 200 kc, loop-to-loop measurements were performed at panel-seam and door-hinge locations. The resulting values were above the measurement capability of 86 db.

The test results indicate an enclosure of high performance at the test frequencies and a high probability of good performance in the intervening range. Since the results are quite favorable and since it was evident that a standard test procedure was being followed, it was agreed that additional measurements were to be performed by Ace Engineering and Machine Co. without Foundation supervision."

Respectfully submitted,
[redacted] 25X1

The sound transmission tests were performed using tape-recorded octave bands of noise as the sound signal. These were played through a loudspeaker located inside the room. The room contained no acoustical treatment or absorptive furnishings, and was sufficiently reverberant that a well-diffused, uniform sound field was produced inside the room which was essentially independent of either source or measuring position. All interior surfaces were therefore exposed to the same sound intensity. The sound level on the source side was taken as a space average of the level inside the room, excluding positions immediately adjacent to any room surface. The room was located in a large, open plant area, which made it impractical to try to measure a room average sound level on the outside. Furthermore, this condition made it possible to compare transmission through different walls of the room, and as mentioned before, the side walls and the rear wall were built with steel and aluminum sound pans, respectively, in order to make this comparison under field conditions. All outside measurements of sound level were made with the microphone as close as possible to the wall without touching it.

The measurements thus obtained are not directly comparable with the Riverbank Laboratories tests on the corresponding wall panels reported previously. The Riverbank tests measure <u>transmission loss</u>, which is a basic property of the wall structure independent of the properties of the room on either side, or of the measuring position on either side. The field tests measure <u>attenuation</u>, which is defined as the difference in sound level existing between two points on opposite sides of the wall, whose position must be specified. The position on either side may be a room average, a close-up position, or any arbitrary point. The attenuation will in general, therefore, depend both on the structure of the wall and on the size and absorption of both rooms and on the measuring positions on both sides. On the receiving side of a wall, the sound level at close-up positions is less affected by the acoustical properties of the receiving room than at any other position, and if the receiving room is large and/or highly absorptive its effect on the close-up sound level is negligible. This was considered to be the case in the Ace Engineering field tests, and the results should be comparable with those obtained with the shielded room set up in any other large, similar outer room. If the outer room is small and/or reverberant, however, the close-up sound levels may be raised somewhat by room reflection, and the measured attenuation will be correspondingly lower.

The Riverbank test values can be compared with the field values by converting the Riverbank data from transmission loss to attenuation, where attenuation is specified in both cases as the difference between the room average level on the source side and the close-up level on the receiving side. This amounts to estimating the close-up levels on the receiving side for the Riverbank data from the measured room-average levels on the receiving side. A theoretical basis for making this estimate has been derived by London. The comparison of the Riverbank data converted to attenuation and the measured field attenuation values for the complete wall structures with steel and aluminum sound pans, respectively, is shown in Fig. 1. There is a considerable discrepancy between the two sets of data, the reasons for which are not immediately clear. One partial explanation is the fact that with a steeply rising frequency curve such as indicated, the sound power transmitted in an octave band is weighted by the attenuation at the lower edge of the band. If a curve is drawn through the lower limits of the octave band data, rather than through the center of each band, the apparent discrepancy is reduced. Such a curve would be approached if smaller band widths had been used for the field tests. Other causes for the remaining discrepancy may be due to incorrect estimates of the conversion of the Riverbank data from transmission loss to attenuation, and to possible differences in the wall structure between laboratory and field. There is no direct data, however, to indicate which causes may be responsible. It will be noted, however, that the shape of the attenuation-frequency curves are quite similar for the Riverbank and field data, and also that the difference between the steel and aluminum sound pans is very nearly the same at all frequencies for both sets of data.

The complete attenuation data obtained at Ace Engineering are listed in Table 2. For the side and rear walls (Series A and B), readings were taken at random positions close to the exterior surface. No systematic variation of attenuation with position was noted for either wall. The remaining readings (Series C, D, and E) were all taken on the front wall under various conditions. The two exterior openings of the ventilating panel were provided with closely fitting removable covers of 16-gauge steel to simulate the sound isolating effect of external ductwork, which was not installed at the time. Tests in Series C were made with both of these covers in place, and in Series D with the lower cover removed. The microphone positions for the two series are shown in Fig. 2. For both series, both of the double doors were closed. The inner door did not have a latch at the time, and it was not possible to adjust the gasketed stops as accurately for maximum sound attenuation as would normally be the case. The effect of adjusting the gasketed stops as well as possible is shown in Series E.

The complete data for the test program at Ace Engineering are plotted in Figs. 3 to 6. The data for the side and rear walls shows that the attenuation for the speech intelligibility frequencies (above 500 cps) was greater than 45 db for both the steel and the aluminum sound pans. Listening tests showed that moderately loud speech delivered at the center of the room could be heard but not understood by close-up listening at either wall in the presence of a comparatively low ambient noise of about 35 db. Tests made by the sponsor with a vibration pick-up showed that speech could not be understood at any position on the wall with steel sound pans, and could be understood by a specially trained listener only at positions over the joints in the all-aluminum wall. For an untrained listener no speech was intelligible at any position through the vibration pick-up.

The data for the front wall showed that there were pronounced sound leaks around the perimeter of the door and at the open vent grille. Listening tests showed that speech was intelligible by close-up listening at both locations. In the case of the vent grille, it was found later when the room was dismantled that a gasket strip was omitted in erecting the ventilation panel. This accounted for much of the leakage, but it also appeared that there was considerable "cross-talk" between the interior grille opening and the immediately adjacent exterior opening through the intervening duct walls. The comparatively high leakage around the perimeter of the door was due to the fact that there was no acoustical gasket in the outer door and as mentioned above the gaskets on the inner door could not be adjusted properly. The attenuation for the front wall measured at positions well removed from any leaks was essentially the same as for the steel side wall. These positions included the cover of the electrical filter box.

PERFORMANCE TESTS - BELL TELEPHONE LABORATORIES

A series of check tests for sound attenuation were made on the room after dismantling and re-erection at Bell Telephone Laboratories, Murray Hill, N. J., on January 26. The room assembly differed acoustically from the previous setup at Ace Engineering in that acoustical tile was applied to the ceiling, the sound pans on all walls were of steel, the inner door was properly fitted with a latch, automatic threshold closer, and gasketed stops, the ventilating panel was fully gasketed, and the ventilating panel itself was modified by adding auxiliary duct walls spaced an inch away from the existing walls at the upper and lower elbows where cross-talk between adjacent grille openings was suspected. Glass fiber insulation was also packed more thoroughly around the inner door frame.

The tests were made in the same manner as at Ace Engineering in that attenuation figures were taken as the difference in sound pressure level between a room average on the inside and close-up readings on the outside. In the BTL tests, however, the demountable room was built in a rather small, reverberant outer room, with a maximum space of only about 8 feet between the two rooms.

Measurements of side wall attenuation were made only on the wall which was farthest (about 8 feet) from the wall of the outer room, at several random microphone positions. Readings on the front wall were made at the positions shown in Fig. 8. Comparative attenuation data for corresponding positions in the Ace and BTL tests are listed in Table 3 and plotted in Figs. 7 and 8. It is seen that the values for the side wall with steel sound pans agree very closely except at the higher frequencies. During the BTL tests, readings were taken also at positions 3 feet and 5 feet away from the side wall. It was noted that the sound level at these distances dropped off with respect to the close-up level for the lower frequencies, but did not change for the 600/1200 octave band or for any higher frequencies. This suggests that the close-up levels in the BTL tests were higher at the upper frequencies than they would have been in a larger, more absorptive room, such as the one at Ace Engineering, and that the attenuation values are therefore correspondingly lower. This explanation could be checked by covering the wall of the outer room opposite the side of the inner room being tested with a thick, highly absorbent layer of glass fiber insulation and comparing the readings with those obtained with a bare wall.

The data for the front wall shows very close agreement between the Ace and BTL tests for the center of the door and a location far from any leaks. There is considerable improvement in the BTL tests both for the door perimeter and the open vent grille. The automatic threshold closer and the gasketed stops on the inner door were carefully adjusted to be as tight as possible and still allow the door to be latched. This resulted in a 6 db improvement at the speech frequencies. The modifications and proper installation of the ventilating panel produced an even larger improvement with respect to the Ace tests. The door perimeter and the open vent grille, however, still have about 10 db less attenuation at the speech intelligibility frequencies than other positions on the front or side walls, and by close-up listening under quiet conditions at these positions moderately loud speech delivered in the center of the room can marginally be understood. Further improvement of the door seals and the ventilating panel would appear desirable.

Spot checks were made by Ace Engineering personnel of the electromagnetic shielding. Results were generally comparable with those obtained on the room as previously erected at the Ace Engineering plant.

The room was erected in 6 working days by a crew of 4 men. The only appreciable difficulty encountered was the installation of the filler panels between the sound pans along the top and bottom edges of the room.

As mentioned before, it is proposed to redesign these panels both for easier installation and to provide for locking in place as a security measure. Acoustical tile were cemented directly to the aluminum ceiling sound pans. These sagged considerably and caused an uneven finished ceiling surface. Cross furring will be used for the final application of the ceiling tile.

SOUND ATTENUATION PERFORMANCE SPECIFICATIONS

The sponsor has requested a suggested set of attenuation values to serve as a performance specification for future rooms. The following is proposed:

"Attenuation shall be defined as the difference between the sound pressure level averaged over the interior volume of the room and the sound pressure level measured at a given point within 3 inches of the exterior surface of the room. In determining the interior average sound pressure level, positions shall be excluded which are within 2 feet of any room surface and which are close enough to the source that the sound level is appreciably higher than the room average. For a wall surface without openings, an average of 5 positions taken at random over the exterior surface shall be used to determine the attenuation for that wall. For surfaces with openings such as doors or grilles, the attenuation shall be recorded for each exterior position chosen and each position shall be specified. Arrangements shall be made so that the sound pressure level drops off at least 3 db and preferably 5 db as the microphone is moved away from the close-up position outside each wall. This condition will be met if the room under test is erected in a very large or absorptive outer room. If any wall of the test room is within 10 feet of a reflective wall of the outer room, it may be necessary to cover the outer room wall with a 2" or 3" layer of glass fiber insulation in order for the sound pressure level to drop off the required amount.

"The sound source shall be a loudspeaker placed at any arbitrary position within the room. The signal shall be octave bands of noise covering at least the following range of frequencies:

75-150 cps
150-300
300-600
600-1200
1200-2400
2400-4800

The octave bands may be obtained by filtering a wide band white noise in either the source circuit, the measuring circuit, or both.

"The attenuation as determined by the above method shall have not less than the following values for an unbroken wall having sound pans of 0.032" aluminum and 20-gauge steel, respectively:

Octave Band	Attenuation, db Aluminum	Steel
75-150	7	10
150-300	15	20
300-600	30	35
600-1200	45	45
1200-2400	50	50
2400-4800	55	55

"The attenuation measured at any point on the exterior of a wall having openings such as a door or vent grilles, and having steel interior sound pans, shall be not less than the following:

Octave Band	Attenuation, db
75-150	10
150-300	15
300-600	30
600-1200	40
1200-2400	40
2400-4800	45

The above specifications are, in the case of the unbroken walls, based on minimum values of field attenuation data obtained both at Ace and Bell Telephone Laboratories, with a tolerance of 2 or 3 db. The specified values for the wall with openings are based on the BTL data. These values are slightly higher than the minimum readings obtained, with the expectation that during the completion of the ARF research program it will be possible to improve the performance of both the door seal and the ventilating panel.

FUTURE PROGRAM

The sponsor has advised that the prototype room now assembled at BTL with be demounted, shipped back to Ace Engineering for possible modifications, and then delivered to the sponsor for erection as a display room. Also, the sponsor is preparing to let a contract to Ace Engineering for a second room to be completed if possible during April. The main improvements which appear desirable in the second room with respect to the prototype are (1) a single door having sound attenuation comparable to the unbroken wall with steel sound pans, and (2) a ventilating panel which is easier to erect and which has improved sound attenuation as measured at the exterior grille opening. Every effort will be made by the Foundation to develop these improvements, as provided for in the current extension of the research program, in time to incorporate them in the second room.

As outlined in previous reports, the development of a satisfactory door depends first on the perfection of a perimeter seal having the required sound attenuation without the necessity of a complicated or inconvenient closing mechanism. The study of this problem with a small scale test facility is continuing. The facility has been modified to allow for measuring higher values of seal attenuation. Recent experiments have shown that very good results are obtained with a door crack which is not tightly closed, but which contains an internal side cavity. An improvement of the order of 20 db was measured as a result of introducing a cavity about 2 inches square in cross section into an open crack 1/8" wide. If this design can be further improved, it will have the advantage that high attenuation can be obtained without the need for applying pressure against a seal.

The performance of the ventilating panel can be improved most readily by separating the supply and exhaust ducts into two separate panels, which may be feasible in the second room. Otherwise, it is proposed to divide the single panel of 40" modular width into two separate sections to reduce cross-talk, and to further modify the design so that the elbows at the ends of the duct silencers are sealed to the grilles more effectively. Modifications resulting from this study also will probably lead to easier job assembly.

Respectfully submitted,

ARMOUR RESEARCH FOUNDATION
of Illinois Institute of Technology

[redacted]

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APPROVED BY:

[redacted]

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ARF Project No. A-157

Table 1

RIVERBANK SOUND TRANSMISSION TESTS ON ACE ENGINEERING PANELS WITH STEEL AND ALUMINUM SOUND PANS

October 18-21, 1960

Test No.	Description	125	175	250	350	500	700	1000	1400	2000	2800	4000	Ave.
TL 61-39	aluminum Lindsay panel and outer skin	15	15	18	23	30	38	46	(50)	51	(50)	50	32
61-40	same, plus steel sound pans (repeat of TL 60-145)	28	32	38	46	56	59	60	(62)	64	(65)	68	50
60-145	same, previous test	29	33	40	47	56	59	61		64		68	51
61-41	same, plus one horizontal stiffening rib	28	33	39	47	56	59	60	(62)	63	(65)	68	50
61-42	same, except 3 horizontal ribs	29	34	40	47	56	58	60	(61)	63	(65)	67	50
61-43	same as 61-40, except aluminum sound pans	22	28	33	43	55	59	61	(63)	64	(66)	68	48
61-44	same, plus one horizontal rib	22	28	33	42	53	58	61	(62)	64	(65)	67	48
61-45	same, except 3 horizontal ribs	24	28	34	43	54	58	60	(62)	64	(65)	67	48

Table 2

FIELD SOUND TRANSMISSION TESTS ON COMPLETE ROOM

Ace Engineering Plant, December 20, 1960

	Attenuation,* db, in Octave Bands					
	75/150	150/300	300/600	600/1200	1200/2400	2400/4800
Series A - Side Wall with Steel Sound Pans						
range and average of 6 positions over wall	8 18 12	19 24 22	36 39 38	47 50 49	54 56 55	61 65 63
Series B - Rear Wall with Aluminum Sound Pans						
range and average of 6 positions over wall	5 14 9	14 20 18	32 35 33	42 50 47	52 57 55	59 63 61
Series C - Front Wall, Steel Sound Pans, Vent Grilles Covered, Door Gaskets not Adjusted						
Position						
1. Center of door	14	23	37	44	45	52
2. Center of vent panel	13	20	35	45	48	54

*Difference in sound pressure level between room average inside and close-up position outside.

Table 2 (Continued)

	Attenuation,* db, in Octave Bands					
	75/150	150/300	300/600	600/1200	1200/2400	2400/4800
3. Edge of filter panel	14	23	37	44	45	52
4. Perimeter of door	18	25	34	37	41	44
5. " " "	16	25	34	36	35	39
6. " " "	15	23	33	36	35	41
7. " " "	14	23	34	34	33	44
Series D - Front Wall, Lower Vent Grille Open, Door Gaskets Adjusted						
Position						
1. Center of door	16	25	36	46	45	52
2. Perimeter of door near knob	15	23	36	38	34	44
3. Center of vent panel	14	20	34	44	46	53
4. Lower vent grille (open)	8	17	22	26	31	42
5. 12" wall panel	15	22	37	44	49	59
6. Filter box	10	24	41	47	55	61

Table 2 (Continued)

	Attenuation,* db, in Octave Bands					
	75/150	150/300	300/600	600/1200	1200/2400	2400/4800
Series E - Perimeter of Inside Door Alone						
range and average of 4 positions						
a. gaskets non adjusted	12 14 12	16 22 19	19 20 19	12 21 18	15 29 22	16 32 24
b. gaskets adjusted	11 13 12	18 22 20	18 22 21	8 23 18	27 29 28	33 39 35

Table 3

COMPARISON OF ACE AND BTL FIELD SOUND TRANSMISSION TESTS

		Attenuation,* db, in Octave Bands						
		75/150	100/300	300/600	600/1200	1200/2400	2400/4800	4800/9600
Side Wall, steel sound pans								
	Ace	11	22	38	49	55	63	
	BTL	18	23	37	45	50	58	55
Front Wall								
Center of door	Ace	16	25	36	46	45	52	
	BTL	16	24	36	45	45	53	52
Edge of door near knob	Ace	15	23	36	38	34	44	
	BTL	13	20	36	44	40	46	49
Open vent grille	Ace	8	17	22	26	31	42	
	BTL	15	22	33	32	39	47	46
Right panel, vents covered	Ace	14	23	36	46	51	57	
	BTL	15	24	37	46	49	56	54

*Difference in sound pressure level between room average inside and close-up position outside.

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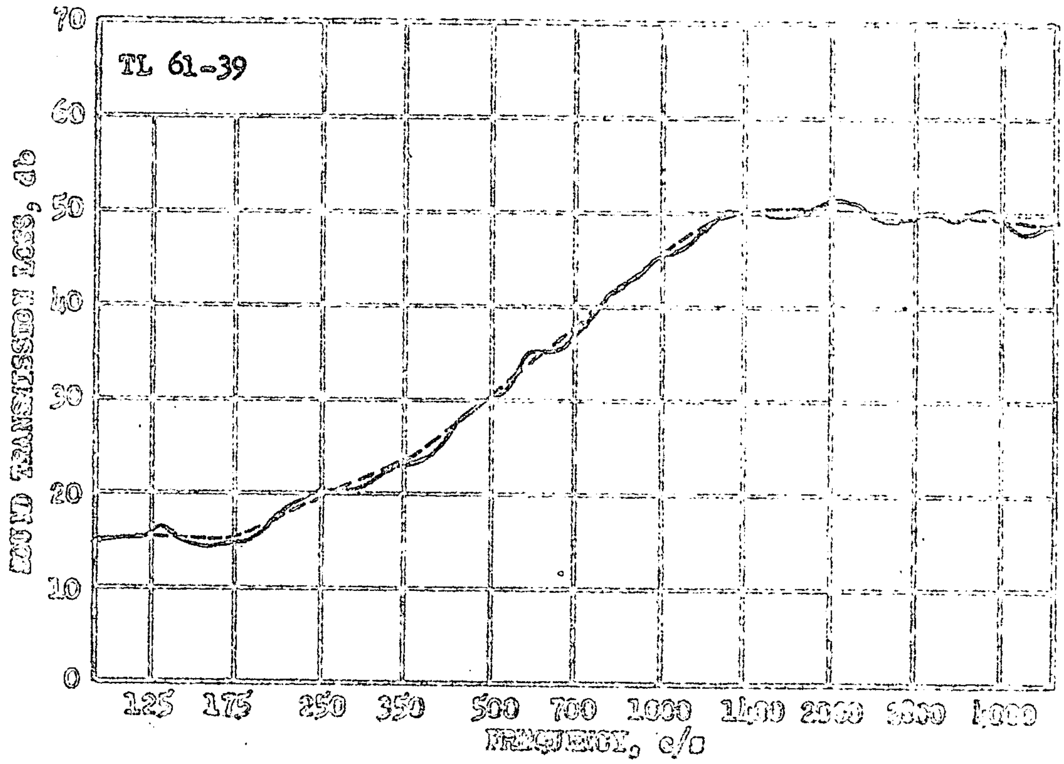
TEST #1, PROJECT A-157



FREQUENCY, c/s	125	175	250	350	500	700	1000	1400	2000	2800	4000	AV
TL, db	15	15	18	23	30	38	46	(50)	51	(50)	50	32

Respectfully submitted,

[redacted] 25X1

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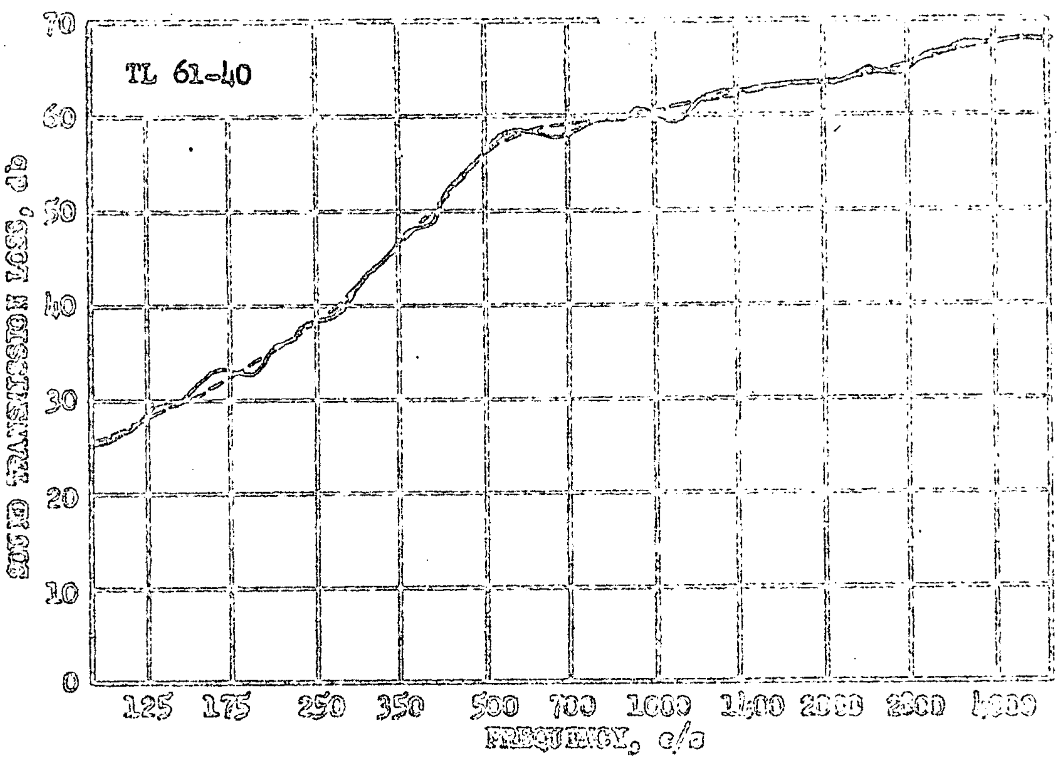
Associate Physicist

[redacted]

RIVERBANK ACOUSTICAL LABORATORIES
ARMOUR RESEARCH FOUNDATION
Geneva, Illinois

TEST #2, PROJECT A-157



FREQUENCY, c/s	125	175	250	350	500	700	1000	1400	2000	2800	4000	AV
TL, db	28	32	38	46	56	59	60	(62)	64	(65)	68	50

Respectfully submitted,

[redacted] 25X1

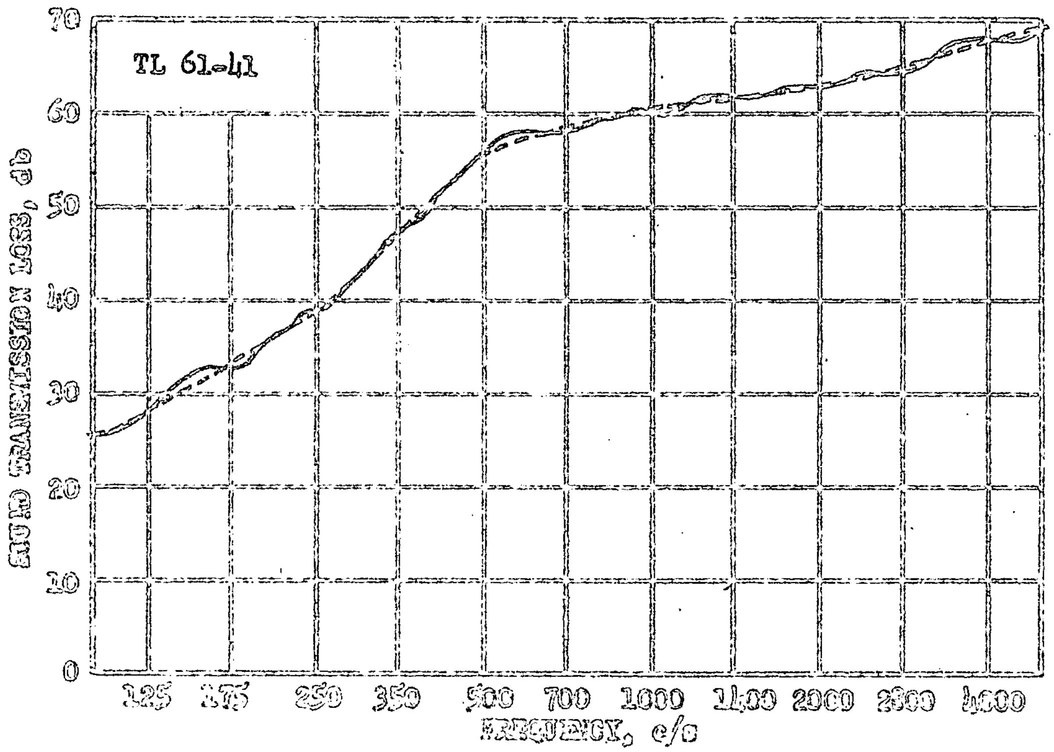
25X1

Associate Physicist

[redacted]

RIVERBANK ACOUSTICAL LABORATORIES
ARMOUR RESEARCH FOUNDATION
Geneva, Illinois

TEST #3, PROJECT A-157



FREQUENCY, c/s	125	175	250	350	500	700	1000	1400	2000	2800	4000	AV
TL, db	28	33	39	47	56	59	60	(62)	63	(65)	68	50

Respectfully submitted,

[redacted]

Associate Physicist

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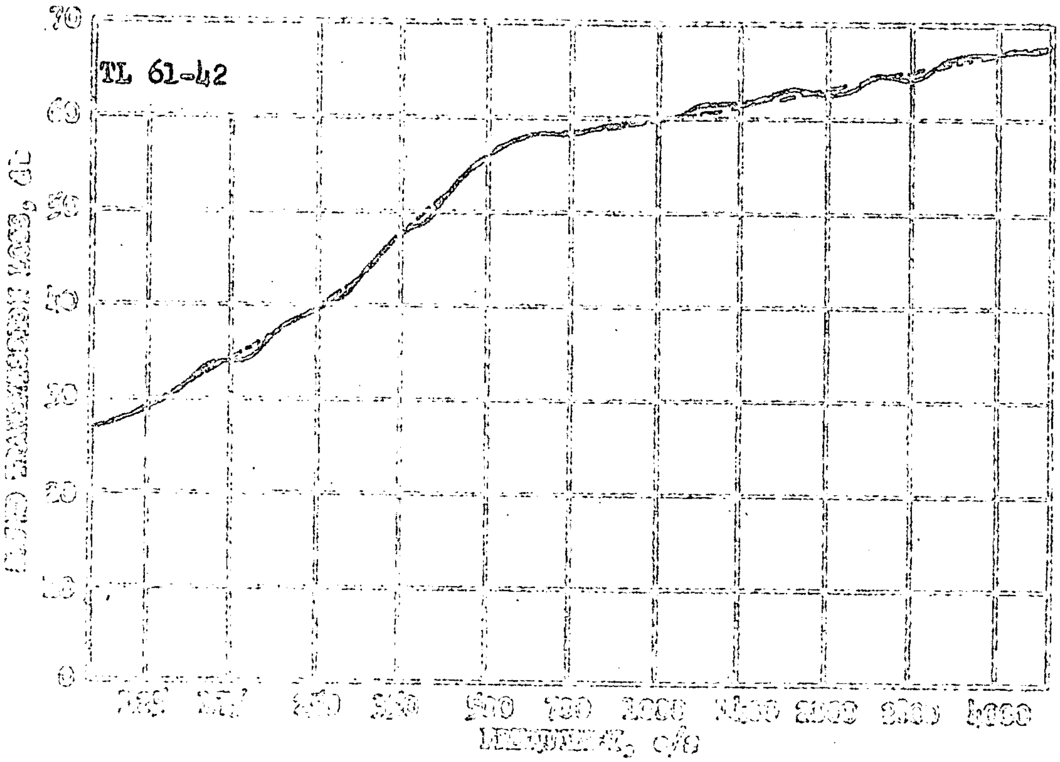
Geneva, Illinois

TEST #4, PROJECT A-157



FREQUENCY, c/s	125	175	250	350	500	700	1000	1400	2000	2800	4000	AV
TL, db	29	34	40	47	56	58	60	(61)	63	(65)	67	50

Respectfully submitted,

[redacted] 25X1

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Associate Physicist

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RIVERBANK ACOUSTICAL LABORATORIES
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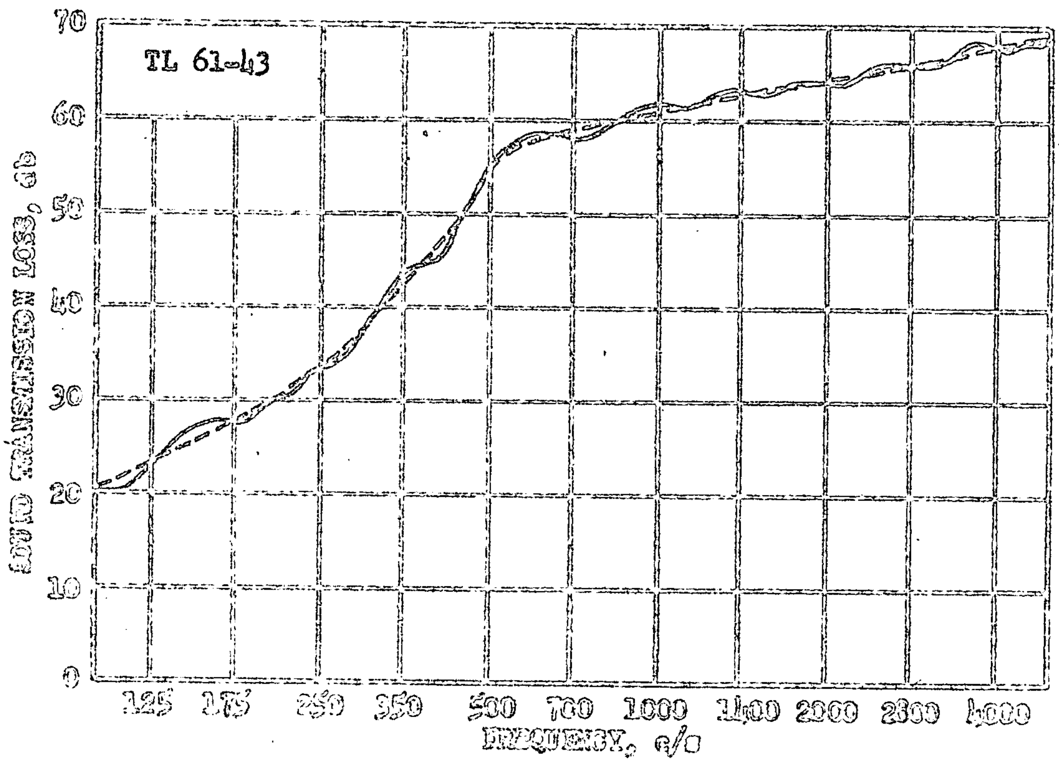
Geneva, Illinois

TEST #5, PROJECT A-157



FREQUENCY, c/s	125	175	250	350	500	700	1000	1400	2000	2800	4000	AV
TL, db	22	28	33	43	55	59	61	(63)	64	(66)	68	48

Respectfully submitted,

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Associate Physicist

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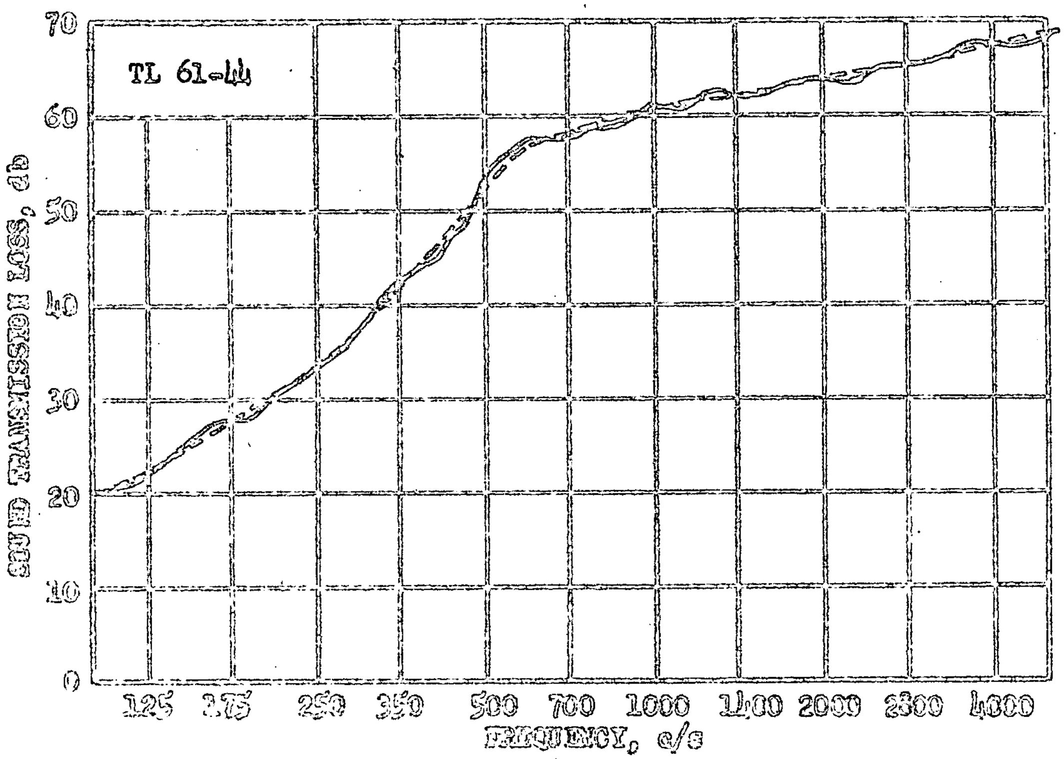
TEST #6, PROJECT A-157



FREQUENCY, c/s	125	175	250	350	500	700	1000	1400	2000	2800	4000	AV
TL, db	22	28	33	42	53	58	61	(62)	64	(65)	67	48

Respectfully submitted,

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25X1

Associate Physicist

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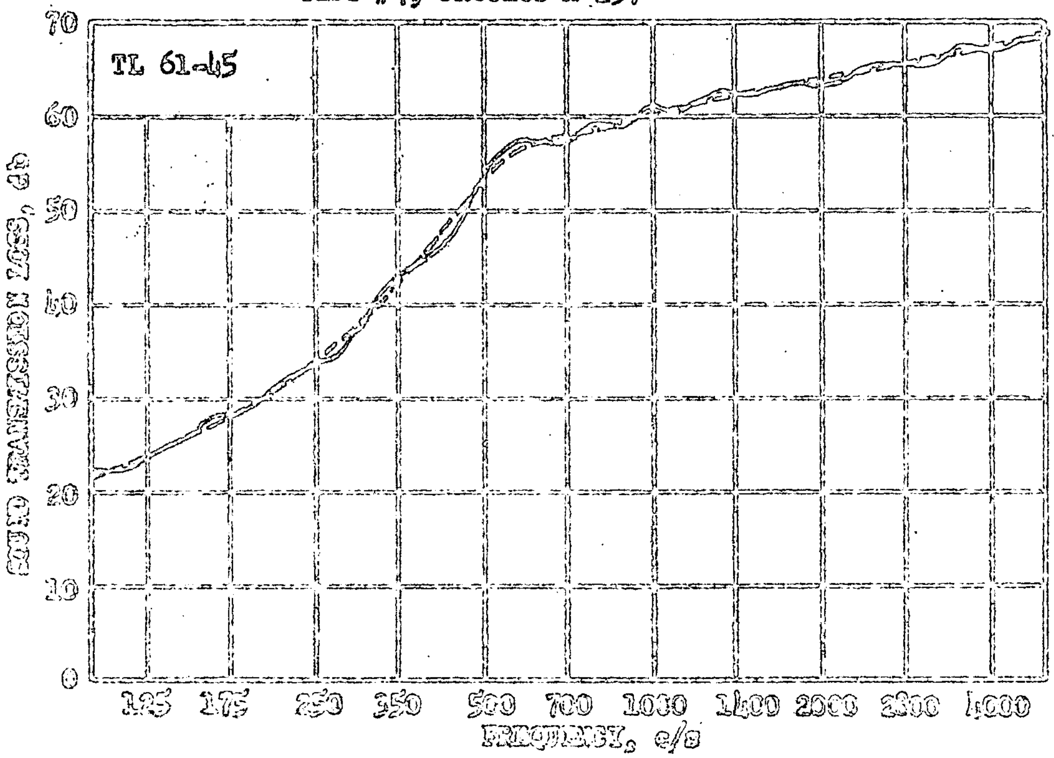
Geneva, Illinois

TEST #7, PROJECT A-157



FREQUENCY, c/s	125	175	250	350	500	700	1000	1400	2000	2800	4000	AV
TL, db	24	28	34	43	54	58	60	(62)	64	(65)	67	48

Respectfully submitted,

[redacted] 25X1

25X1

Associate Physicist

[redacted]

RIVERBANK ACOUSTICAL LABORATORIES
ARMOUR RESEARCH FOUNDATION
Geneva, Illinois

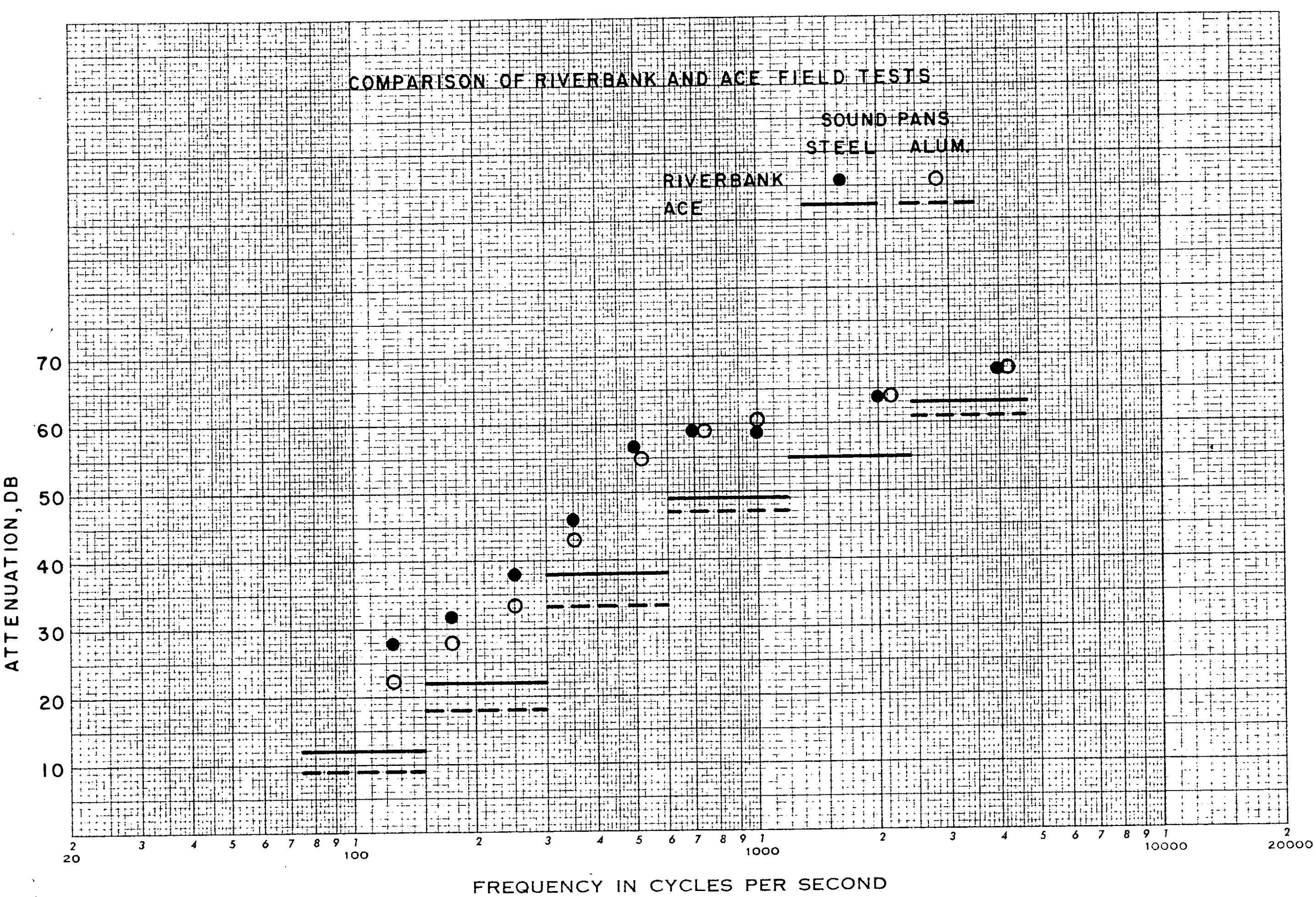
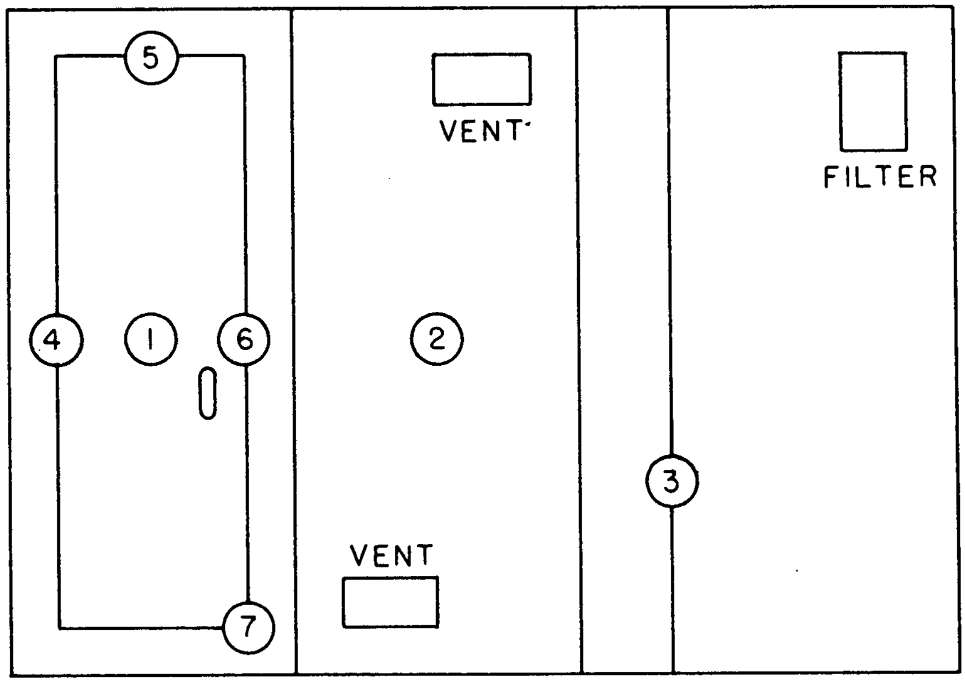
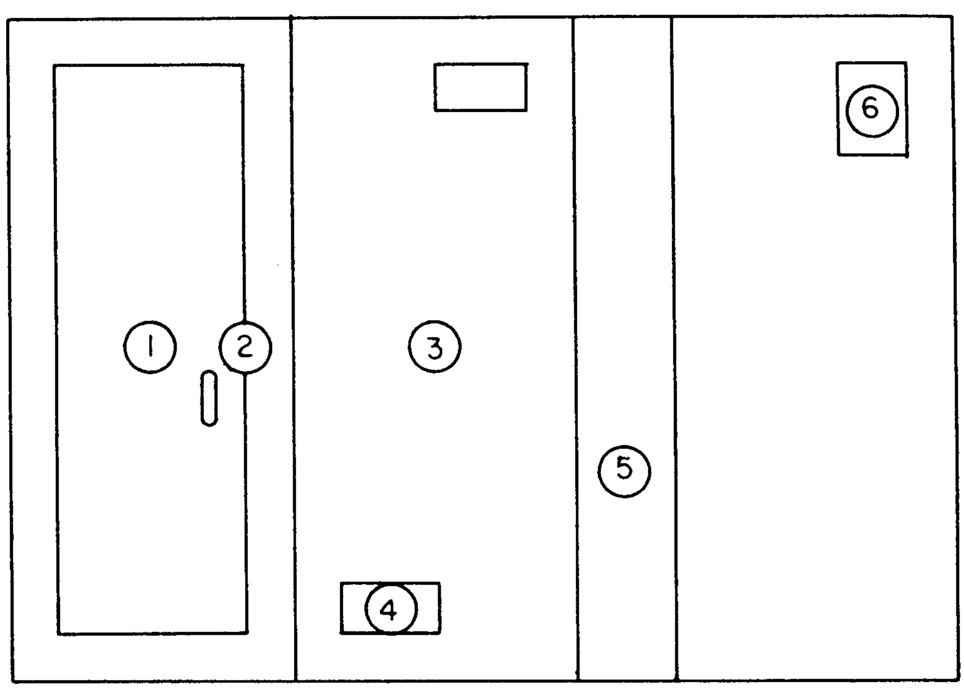

COMPARISON OF RIVERBANK AND ACE FIELD TESTS
SOUND PANS
STEEL ALUM.
RIVERBANK
ACE
ATTENUATION, DB
70
60
50
40
30
20
10
2
20
3
4
5
6
7
8
9
1
100
1000
10000
20000
FREQUENCY IN CYCLES PER SECOND

FIG. I



SERIES C ,VENTS CLOSED



SERIES D, LOWER VENT OPEN

FIG. 2

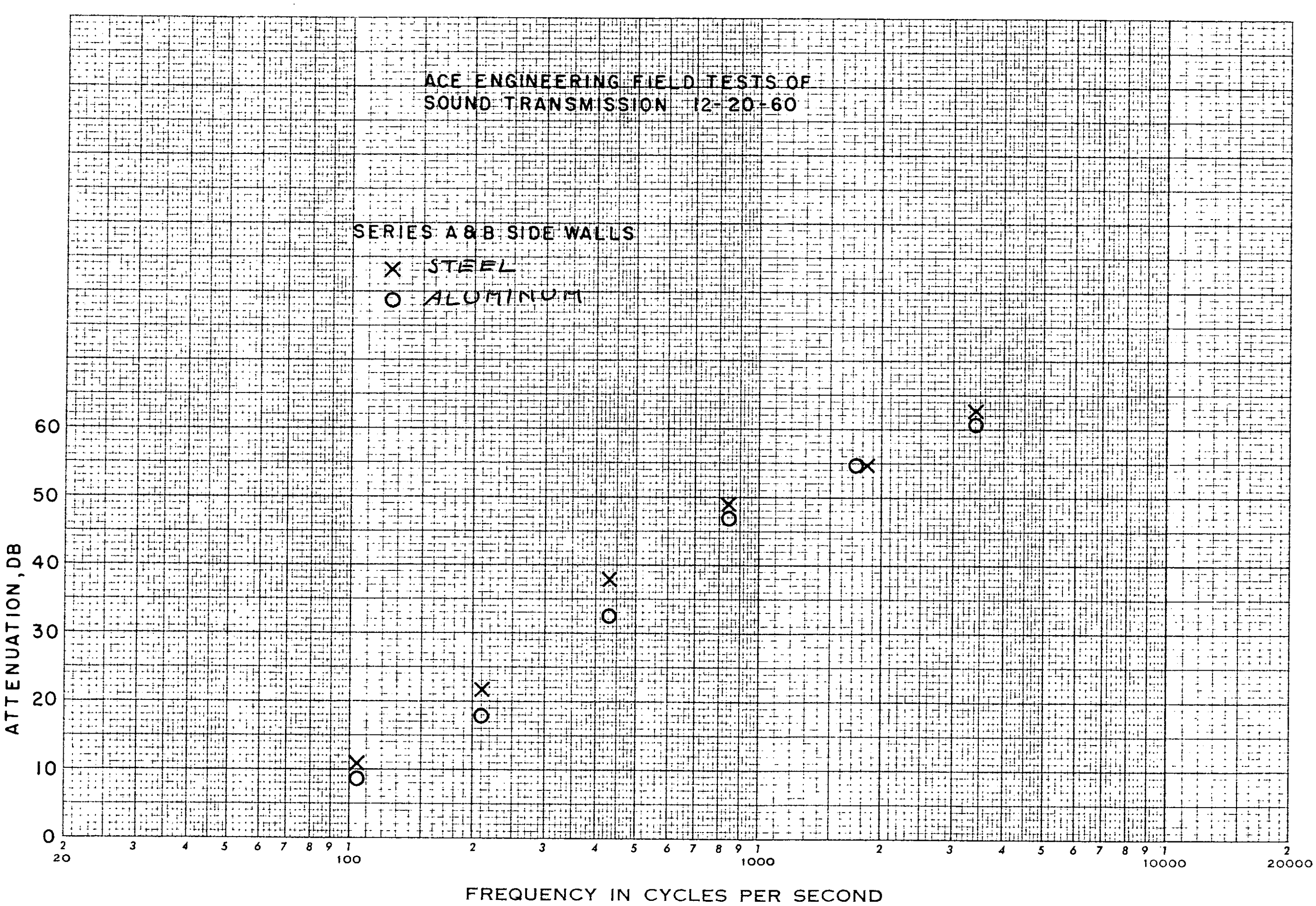

ACE ENGINEERING FIELD TESTS OF
SOUND TRANSMISSION 12-20-60
SERIES A & B SIDE WALLS
X STEEL
O ALUMINUM
ATTENUATION, DB
0
10
20
30
40
50
60
20
100
1000
10000
20000
FREQUENCY IN CYCLES PER SECOND

FIG. 3

CLEARPRINT PAPER CO NO C1 FREQUENCY

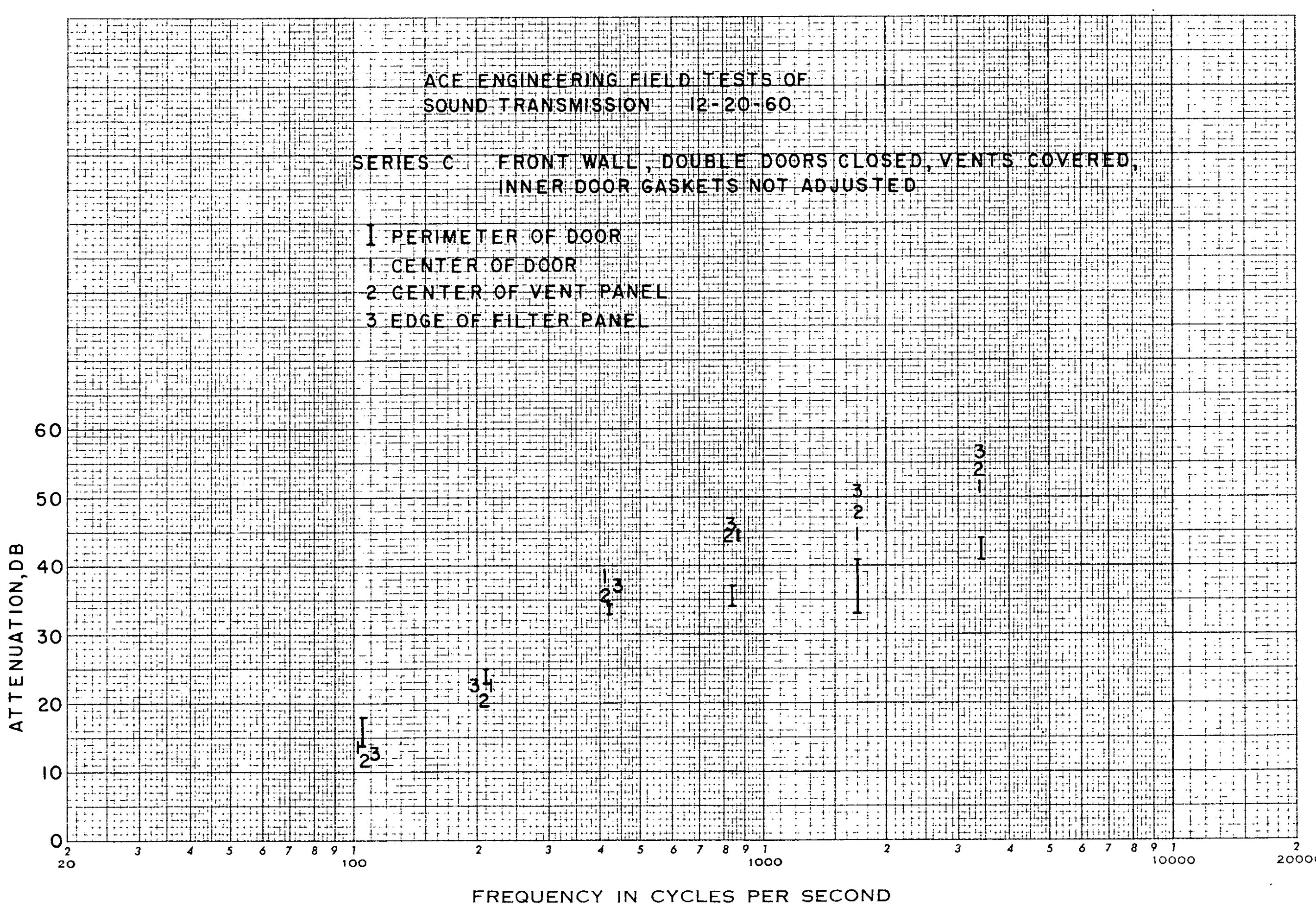


FIG. 4

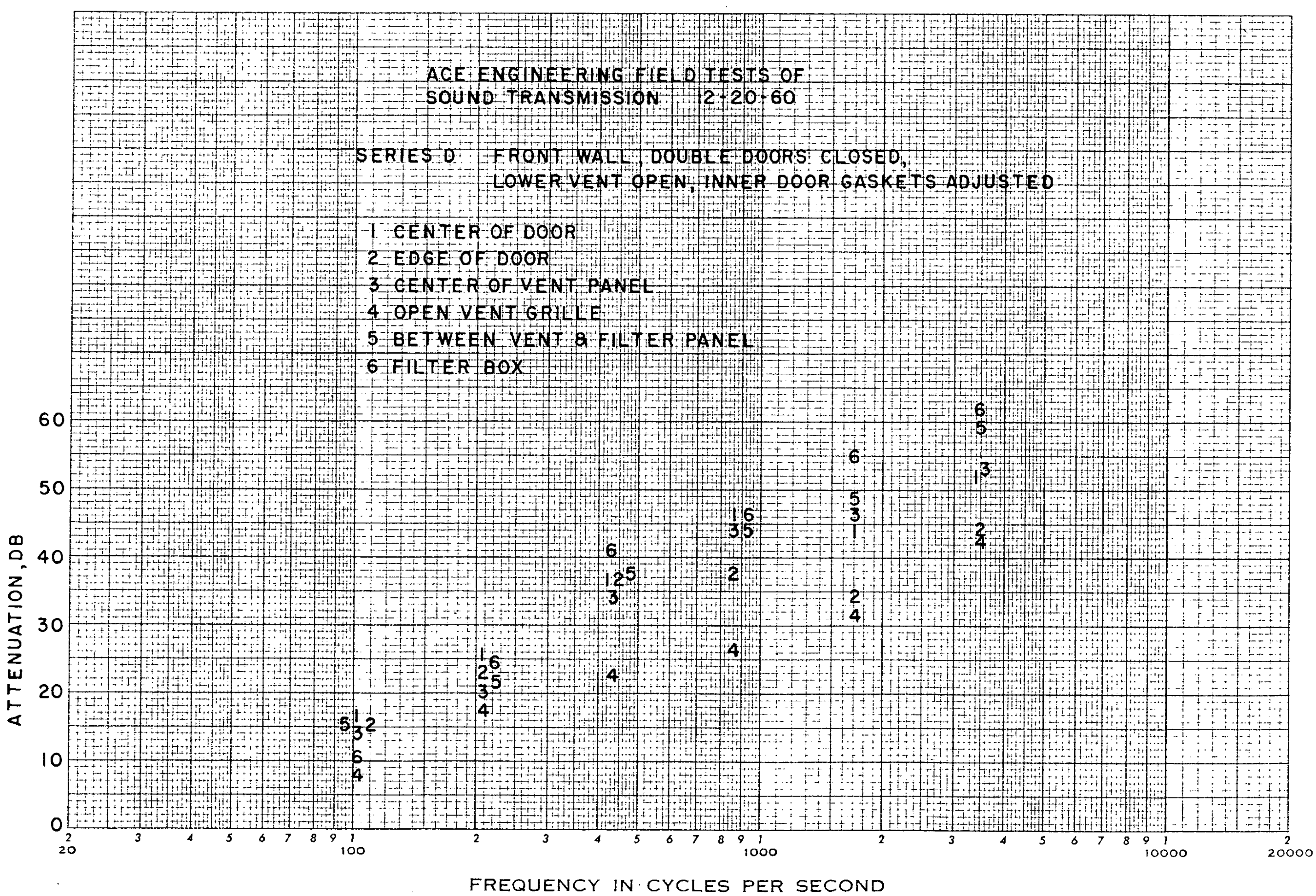

ACE ENGINEERING FIELD TESTS OF
SOUND TRANSMISSION 12-20-60
SERIES D FRONT WALL, DOUBLE DOORS CLOSED,
LOWER VENT OPEN, INNER DOOR GASKETS ADJUSTED
1 CENTER OF DOOR
2 EDGE OF DOOR
3 CENTER OF VENT PANEL
4 OPEN VENT GRILLE
5 BETWEEN VENT & FILTER PANEL
6 FILTER BOX
ATTENUATION, DB
FREQUENCY IN CYCLES PER SECOND

FIG. 5

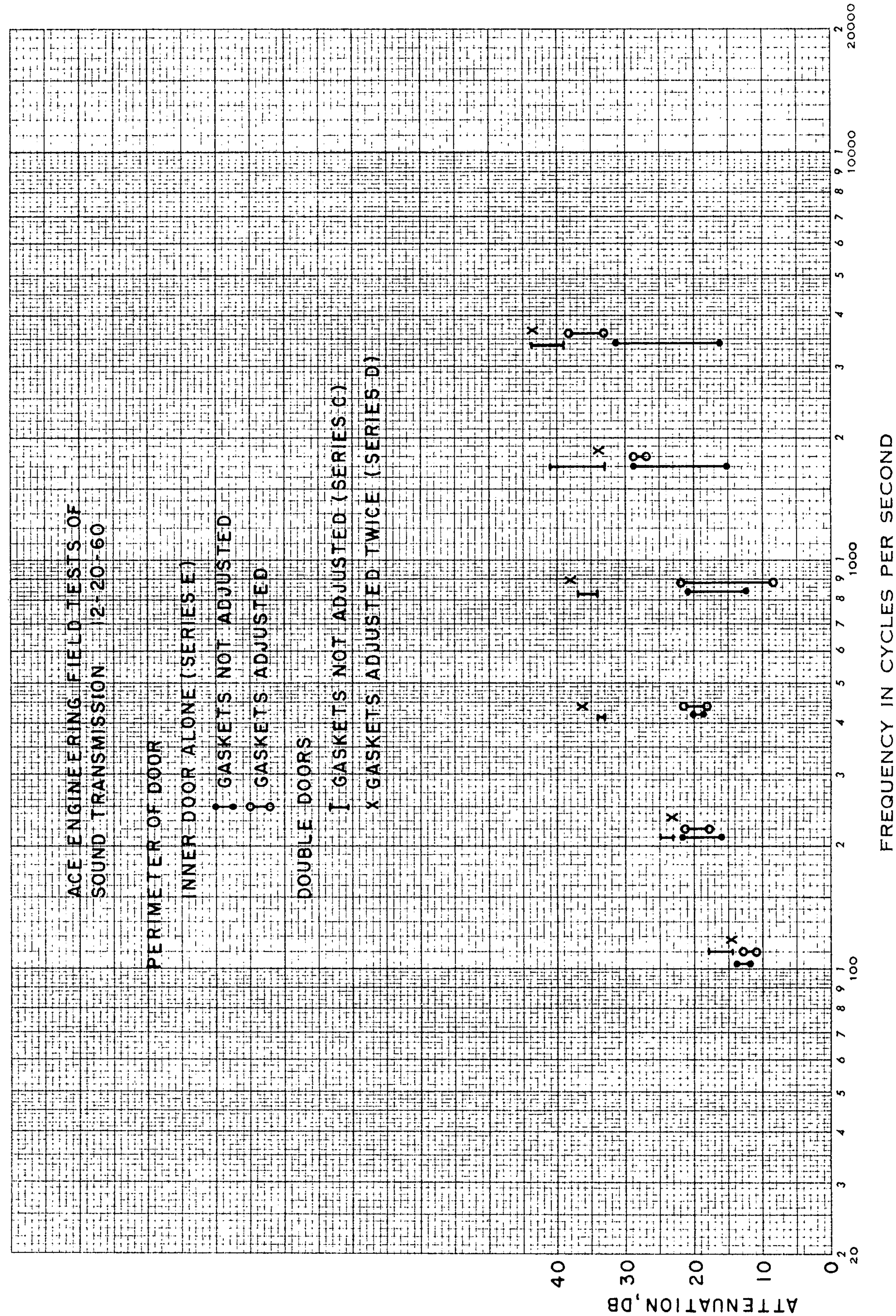

ACE ENGINEERING FIELD TESTS OF
SOUND TRANSMISSION 2-20-60
PERIMETER OF DOOR
INNER DOOR ALONE (SERIES E)
GASKETS NOT ADJUSTED
GASKETS ADJUSTED
DOUBLE DOORS
I GASKETS NOT ADJUSTED (SERIES C)
X GASKETS ADJUSTED TWICE (SERIES D)
ATTENUATION, DB
0
10
20
30
40
20
100
1000
10000
20000
FREQUENCY IN CYCLES PER SECOND

FIG. 6

CONFIDENTIAL

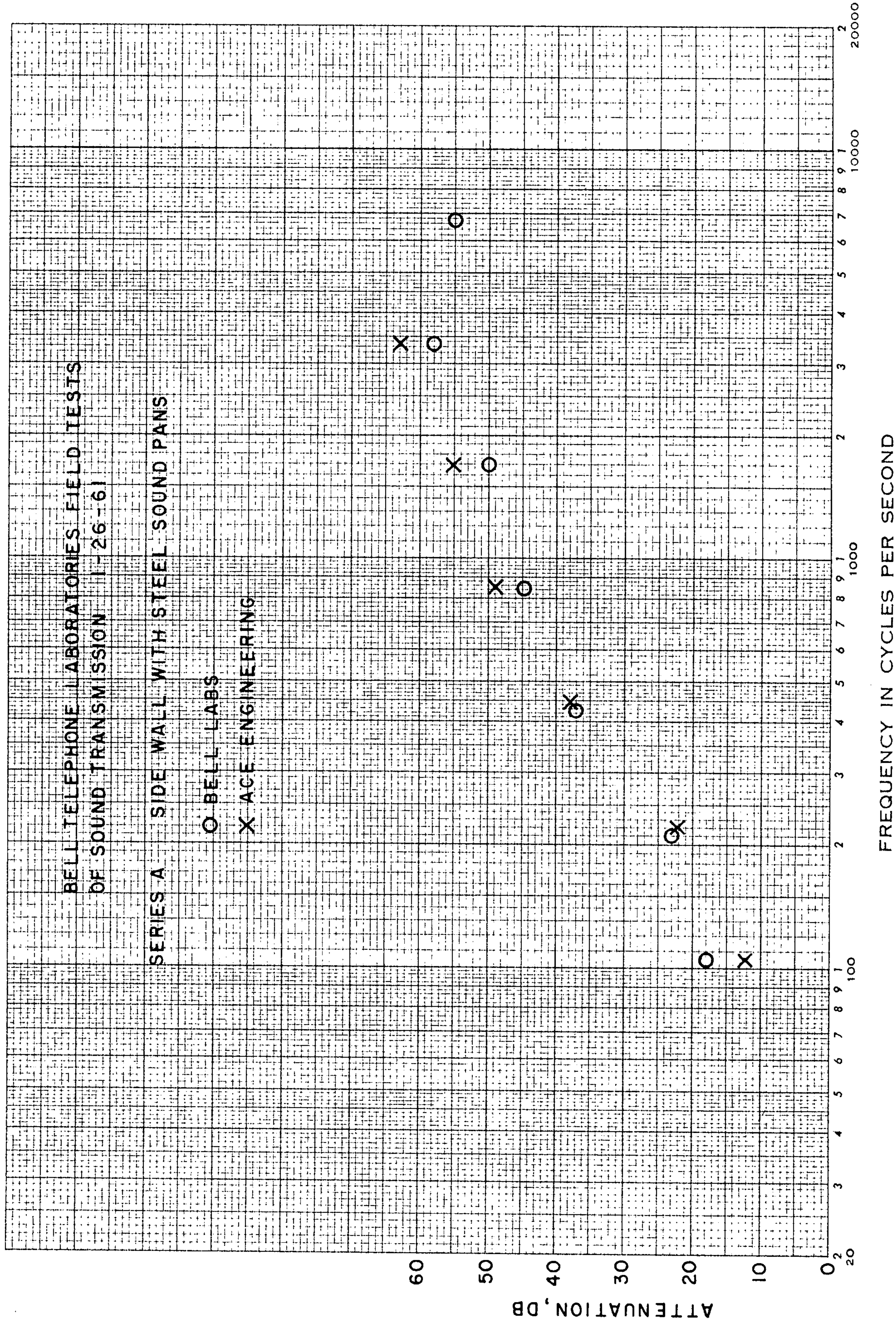
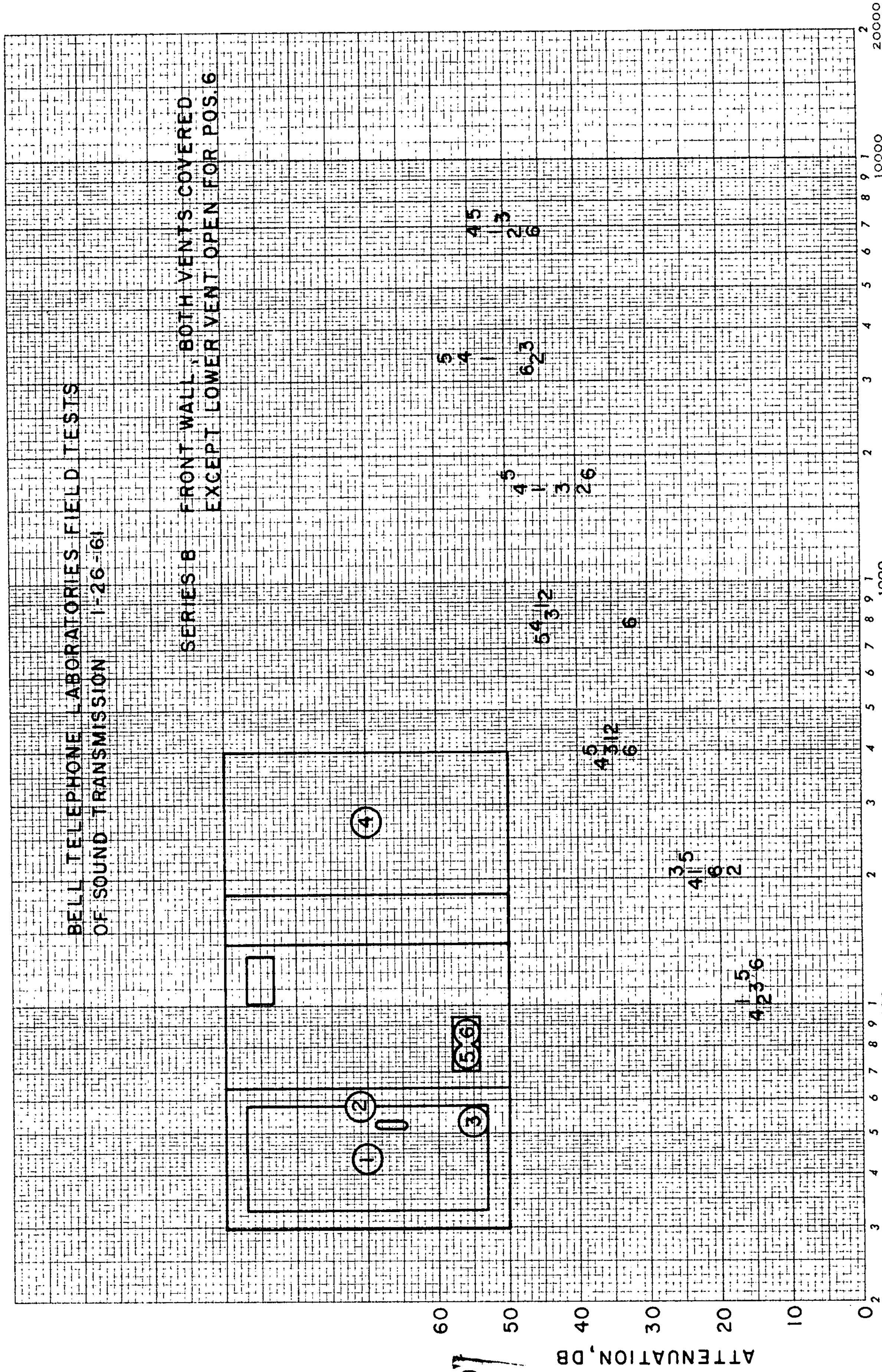


FIG. 7

CONFIDENTIAL

CONFIDENTIAL



FREQUENCY IN CYCLES PER SECOND

FIG. 8

CONFIDENTIAL

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